LTC

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INSTRUMENT
INSTRUCTIONS

SENSITIVE RESEARCH
INSTRUMENT CORPORATION
NEW ROCHELLE, N.Y.

Symbol of Quality

ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

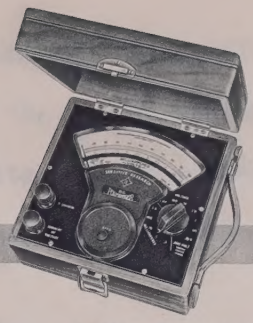
Instrument No.

ENSITIVE RESEARCH INSTRUMENT CORPORATION

Electrical Instruments of Precision

Electrical Instrument Engineers Since 1919

310 MAIN STREET · NEW ROCHELLE, N.Y.



MODEL LTC CONSOLE INSTRUCTION MANUAL

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INTRODUCTION

1. DESCRIPTION. The Model LTC SENSITIVE RESEARCH AC-DC LABORATORY STANDARDIZING TEST CONSOLE is a highly accurate, wide range instrument for the standardizing of AC and DC voltages or currents over a very wide range of limits. It is a direct reading, easily operated, self-contained unit, that demands a minimum of set-up and no additional standardizing equipment.

Both AC and DC use a precise 1 milliampere incremeter *movement as a reference. The movement instead of reading "zero" to "full scale" is used as an error indicator over a plus or minus 5% range. The scale is marked from 5% low through zero to 5% high and reads the error of the actual voltage applied to the present value. By adjusting the voltage until the indicator reads "zero", the console can be used as a precise calibrator.

Direct current measurements are made using internally switched decade resistance units. For voltage, four decades are connected in series with the 1 milliampere movement to provide a 1000 ohm per volt multiplier with .1 volt increments. The DC current measurements are made by shunting the 1 milliampere incremeter movement with a special decade shunt circuit developed by SRIC.

AC measurements are made using internally mounted vacuum thermocouples as AC to DC transfer devices; measurements of the DC transfer quantities are made with the incremeter movement. Special compensation circuits are provided in both the voltage and current sections which eliminate errors due to variations of heater resistance with current and permanent changes caused by overloads.

*SRIC Laboratory Standard Instrument in which the high comparative accuracy of a differential instrument is combined with a highly stable reference source to produce high absolute accuracies.

2. SPECIFICATIONS.

AC Volts-Range .5 volts to 1110.0 volts in .1 volt incremeters at 100 ohms per volt.

AC Current-Range 2 milliamperes to 11.100 Amperes in 1 ma. increments. Voltage drop 2 volts, all ranges.

DC Volts-Range .5 volts to 1110.0 in volt increments at 1000 ohms per volt.

DC Current-Range 1 milliampere to 11.100 amperes in 1 ma. increments. Voltage drop 2 volts, all ranges.

Accuracy-All ranges .05% of actual readings.

Power Supply-Requires 115 volt 60 cycles source, plus 2(6 volt) storage batteries and a regulated supply of 1110 volts capable of furnishing 50 ma. plus current drain of instrument under test. (A 500 volt supply can also be used if desired. This limits testing to the 0-500 volt ranges.)

Overall Case Dimensions - Height 29" Width 30"
Depth 21-7/8" Weight 135 lbs. approx.

For operation on DC & AC to 25,000 cycles.

.5 volts to 99 volts - DC to 25 KC - ±.05%

100 volts to 199 volts - DC to 20 KC - ±.05%

200 volts to 399 volts - DC to 12.5 KC - ±.05%

400 volts to 1111 volts - DC to 2.5 KC - ±.05%

.002 amps to .499 amps - DC to 20 KC - ±.05%

.500 amps to 1.99 amps - DC to 10 KC - ±.05%

2.00 amps to 11.11 amps - DC to 5 KC - ±.05%

3. CONTROLS

MEASUREMENTS SELECTOR, 4 pos. sw. Selects type of measurements to be made.
LOW VOLTAGE SELECTOR, 3 pos. sw. Selects 6v, 12v, or off position.
CURRENT SELECTOR, Selects low or high DC current.
DC SUPPLY SELECTOR, Selects low or high voltage supply.
DECADE RANGE SELECTORS, Selects desired range of AC or DC voltage or current.
DC CURRENT AND VOLTAGE CONTROLS, Control DC power supply.

TRANSFER CONTROLS:

a. Transfer switch, selects thermocouple balance or DC substitution circuit.
b. AC BALANCE CONTROLS, Adjustment controls for the balancing voltage for the thermal junction output.
c. DC SUBSTITUTION CONTROLS, Adjustment controls for the DC reference voltage.

DC POWER SWITCH, Turns DC power on or off.
AC POWER SWITCH, Controls AC power for the entire unit.
GALVANOMETER KEYS, Close galvanometer circuit to indicate balance in thermocouple junction circuit. Coarse & Fine balance keys.

THEORY OF OPERATION

1. DC MEASUREMENTS.

a. DC VOLTAGE. Four decade resistance units are connected directly in series with the one milliampere incremeter movement. These provide additive

DC Current-Range 1 milliampere to 11.100 amperes in 1 ma. increments. Voltage drop 2 volts, all ranges.

Accuracy-All ranges .05% of actual readings.

Power Supply-Requires 115 volt 60 cycles source, plus 2(6 volt) storage batteries and a regulated supply of 1110 volts capable of furnishing 50 ma. plus current drain of instrument under test. (A 500 volt supply can also be used if desired. This limits testing to the 0-500 volt ranges.)

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THEORY OF OPERATION

1. DC MEASUREMENTS.

a. DC VOLTAGE. Four decade resistance units are connected directly in series with the one milliampere incremeter movement. These provide additive

increments of .1, 1, 10, and 100 volts so that up to 1,110 volts in .1 volt steps is available. The resistance of the DC ranges is 1000 ohms per volt.

b. DC CURRENT. The incremeter movement functions as a 1 ma., 2 volt indicator in the DC current application. Special decade units developed by SRIC shunt the movement in such a way that the combination always has a two volt drop when current, equal to the value indicated on the decade selectors, is passing through the DC current terminals.

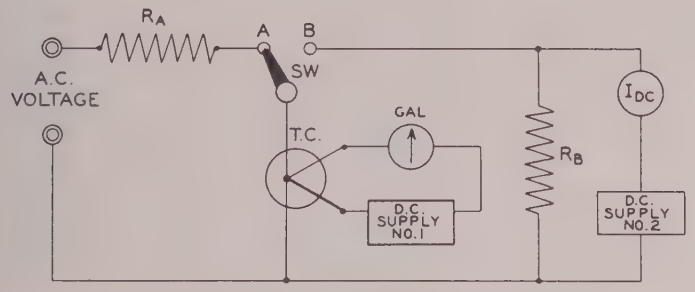
2. AC MEASUREMENTS

a. GENERAL. The circuits for AC voltage and current use vacuum thermocouples as AC to DC transfer devices. Vacuum thermocouples consist of a heater of fine wire, and a thermo-junction of two dissimilar metals. The junction of the dissimilar metals is attached to the center of the heater wire by means of an electrically insulating, but thermally conducting bead of material. The whole unit is enclosed in a small evacuated glass bulb. When a current is sent through the heater wire it reaches an elevated temperature and the attached thermal junction develops an output voltage proportional to the heat generated by the current in the heater. The output being dependent on the heater temperature which is a square law function of the heater current, can be interpreted in terms of the true RMS value of the heater current. The RMS value of the alternating currents applied can then be evaluated by substituting a KNOWN DIRECT CURRENT. The direct substitution of DC for AC can achieve an accuracy of transfer of better than .01% for the AC-DC conversion. In order to achieve the wide range of voltage and current which can be measured with the LTC console, TWO different thermocouples are used, each being assigned a particular circuit. The voltage transfer section uses a 10 milliampere thermocouple, A 1.5 milliampere thermocouple is used for the current section.

For voltage measurements, series DECADE RESISTORS are added to the thermocouple heater circuit to obtain the desired ranges. For current measurements the heater is shunted by a series of accurate resistances to obtain the desired ranges. In both cases, the developed e.m.f. of the thermocouple junction is

balanced out against an internal millivolt supply to obtain a "null" indication of the galvanometer. After a balance is obtained, the heater is then switched to a second internal DC source and this source adjusted to RETURN THE GALVANOMETER AGAIN TO ZERO. The value of this DC current or voltage necessary to duplicate the junction output produced by the AC voltage or current is REFERENCED to the INCREMETER MOVEMENT for measurements.

b. AC VOLTAGE. The basic AC to DC voltage transfer circuit is shown in Figure 1.



BASIC A.C.-D.C. VOLTAGE TRANSFER CIRCUIT Fig. #1

If an AC voltage is impressed across R_A and the thermocouple heater by placing the switch in position "A", current will flow through the heater and produce a DC junction output voltage. DC supply No. 1 can be adjusted to give a stable output EXACTLY EQUAL and opposite to the couple output. At this point the galvanometer will indicate zero output by a "null" (no motion of its light image.)

If we now change the switch (SW) to the "B" position and adjust DC supply #2 until the galvanometer returns again to zero (null), we know that the thermocouple output is again the SAME as when the switch was in position "A" and hence the heater current is now IDENTICAL to that which was produced by the original AC voltage.

In Position "A", $I_H = \frac{V_{AC}}{R_A + R_H}$

In Position "B", $I_H = \frac{I_{DC} \times R_B}{R_B + R_H}$

I_H = Heater Current

R_A = Range Resistor

R_H = Heater Resistance

V_{AC} = AC Input Voltage

I_{DC} = DC Reference Current

R_B = Compensation Resistor

Since the effective value of I_H is the same for both positions, then

$$I_H = \frac{V_{AC}}{R_A + R_H} = I_{DC}\frac{R_B}{R_B + R_H}$$

If $R_A = R_B$, $V_{AC} = I_{DC}R_A$

Thus, by using the compensation resistor R_B, the heater resistance R_H drops out of the formula and the accuracy of V_{AC} depends only on R_A and I_{DC}.

c. AC CURRENT. The basic AC to DC current transfer circuit is shown in Figure 2.

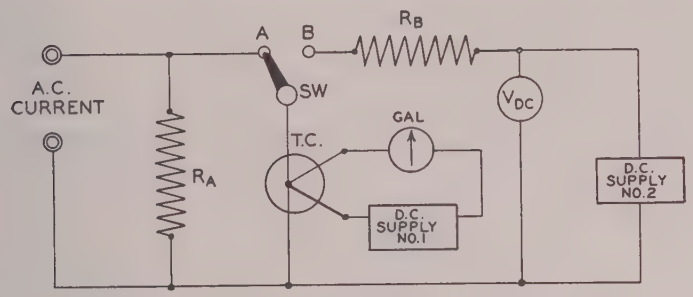


Fig. #2 BASIC A.C.-D.C. CURRENT TRANSFER CIRCUIT

For AC current a very similar circuit is used to eliminate the resistance of the thermocouple from the calibration accuracy. The circuit of this is shown in Fig. 2. The AC current is put through a shunt "R_A" and the thermocouple is connected directly across the shunt when the switch is in the "A" position. Similar to the operation for AC volts, the thermocouple output is balanced to zero by means of a stable DC supply #1. The thermocouple is then switched to the "B" position and a DC voltage applied through a compensating resistance "R_B" to produce the same thermocouple output as evidenced by the return of the galvanometer to zero.

In position "A", $I_H = I_{AC} \times \frac{R_A}{R_A + R_H}$

In position "B", $I_H = \frac{V_{DC}}{R_B + R_H}$

Since the effective value of I_H is the same for both positions then,

$$I_{AC}\frac{R_A}{R_A + R_H} = \frac{V_{DC}}{R_B + R_H}$$

If $R_A = R_B$, $\frac{I_{AC}R_A}{R_A + R_H} = \frac{V_{DC}}{R_B + R_H}$ or $I_{AC}R_A = V_{DC}$

Therefore, using this circuit, I_{AC} can be determined knowing R_A and V_{DC} only. R_H does not appear in the final equation.

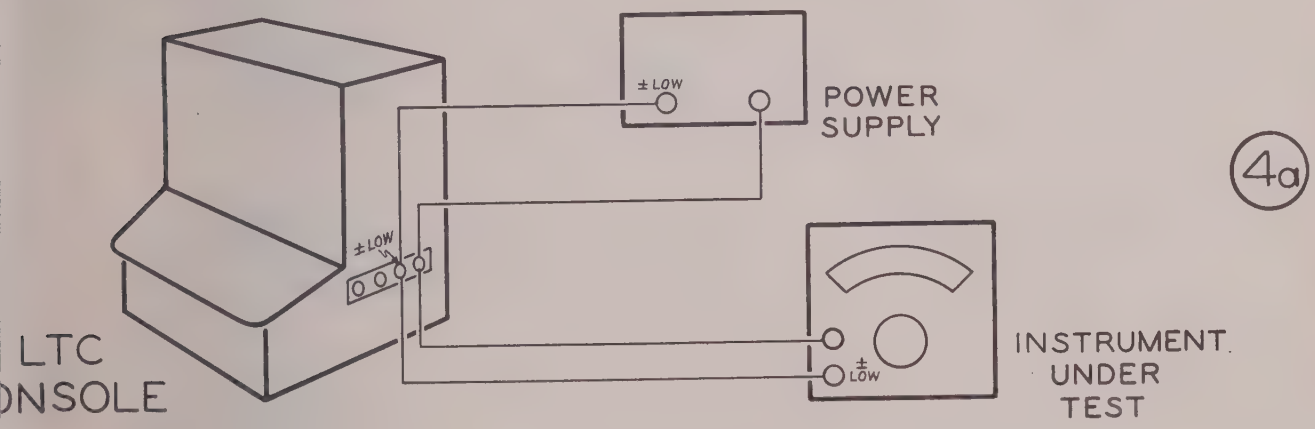
In both the AC voltage and current sections of the LTC, the compensation resistance indicated by R_B should be EXACTLY equal to R_A. In the console, the compensation resistors and the range resistors are ONE and the SAME set of values.

A relay is used to switch the resistance from the input circuit to the compensation circuit. This technique eliminates any variation that might be encountered by using separate resistors.

OPERATING INSTRUCTIONS

1. CONNECTIONS

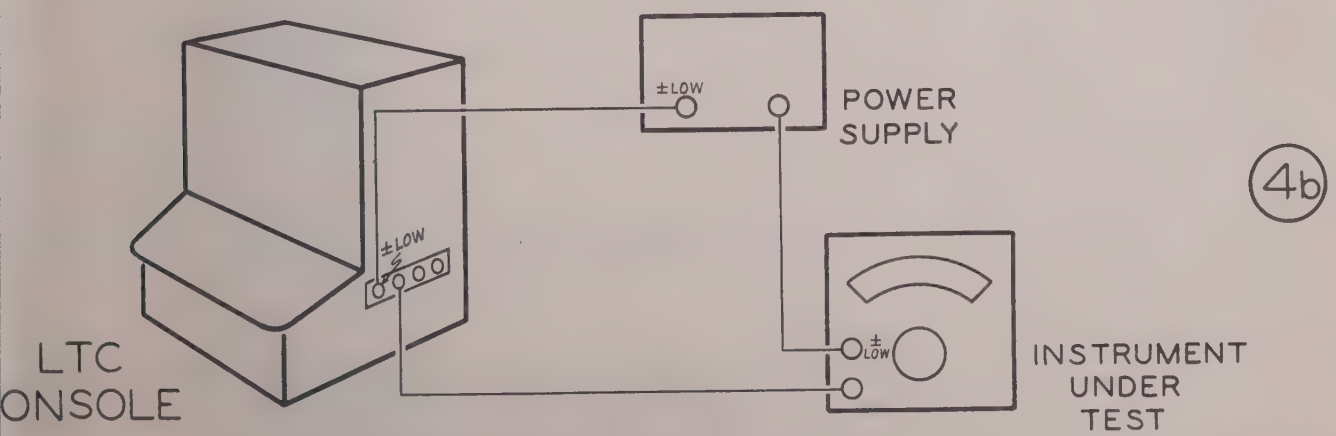
a. AC VOLTAGE. The power supply and the instrument to be calibrated are connected in parallel with the volt terminals of the LTC (See Figure 4A.)



4a

A.C. VOLTAGE

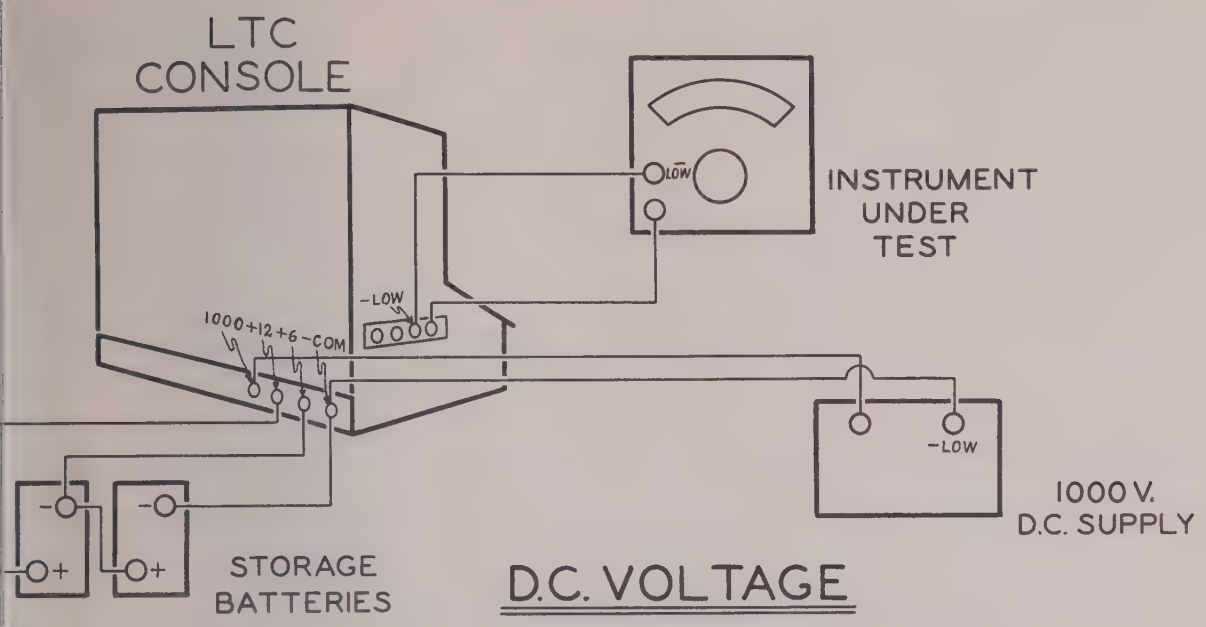
b. AC CURRENT. The power supply and the instrument to be calibrated are connected in series with the AC current terminals of the LTC (See Fig. 4B.)



4b

A.C. CURRENT

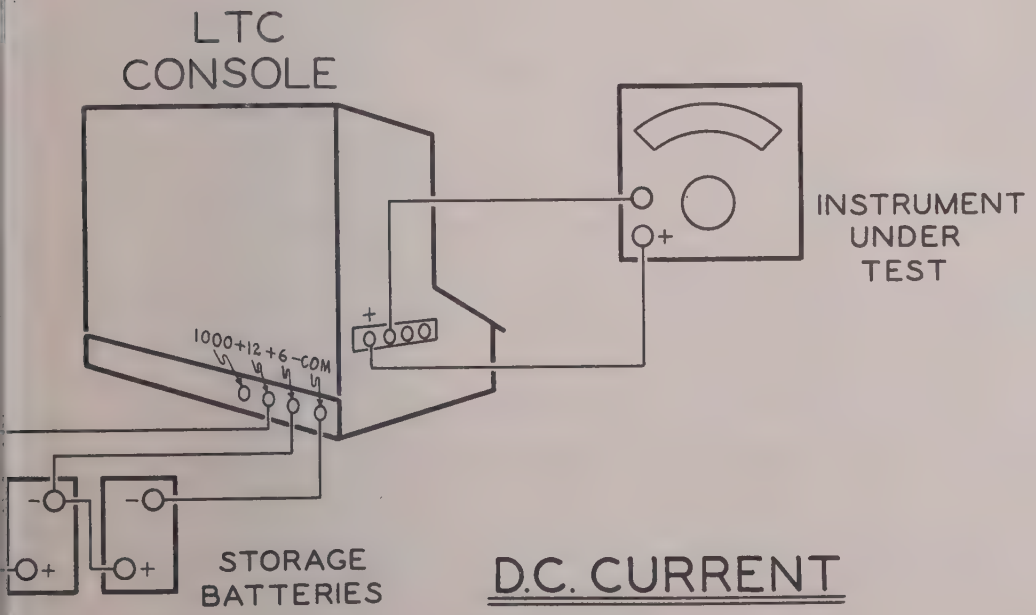
c. DC VOLTAGE. The indicated DC supplies are connected to the rear of the console. The instrument under test is connected directly across the DC volt terminals. (See Figure 4C.)



4c

D.C. VOLTAGE

d. DC CURRENT. The indicated DC supplies are connected to the rear of the console. The instrument under test is connected in series with the DC current terminals. (See Figure 4D.)



4d

D.C. CURRENT

NOTE: ONLY ONE set of Terminals (AC volts, AC current, DC volts or DC current) should be used at any one time. The other pairs of terminals should not have any connections made to them since accuracy may be effected.

CAUTION: When making AC measurements, special care and technique is necessary due to the overload limitations and slow response time of thermocouples.

OVERLOAD LIMITATIONS. At rated current thermocouple heater wires run at a high temperature. If the heater current is doubled the heater temperature is 4 times normal and becomes dangerously high. For this reason when the circuit selector is in the AC input position, the voltage or current across the input terminals should never greatly exceed the range selector setting. Overloads of more than 100% will damage or probably burn out the thermocouple.

RESPONSE TIME. Since the DC junction e.m.f. of the thermocouple is dependent on the temperature of the heater wire, there will be a lag in response of about 15 seconds for the heater wire to reach thermal equilibrium. This will be evidenced on the LTC galvanometer whenever the heater current is varied. The AC measurements will, therefore, be slower and require more care than the DC measurements.

2. PROCEDURE

Turn the AC power supply switch on. Allow 15 minutes warm up for full accuracy.

a. DC VOLTAGE. -- (to calibrate)

1. Connect instrument and appropriate supply to the console as shown in Figure 4C.

2. Set measurement selector to DC volts position.

3. Set DC voltage decade selectors to desired range.

4a. If voltage is below 10 volts, set the DC supply selector to "up to 10 volts" position and set the low voltage selector to the 6 or 12 volt position.

4b. If voltage desired is above 10 volts, set the DC supply selector to "above 10 volts" and use the external high voltage supplied.

5. Set the DC voltage and current controls fully counter clockwise, then turn the DC power switch on.

6. Adjust the DC current and voltage controls in sequence of coarse, medium, fine, very fine until zero percent is obtained on the error indicator.

7. Read instrument under test.

e. AC VOLTS. -- (to calibrate)

1. Connect instrument and appropriate supply to the console as shown in Fig.4A.

2. Set transfer switch to DC substitution position.

3. Set measurement selector to AC volts position.

4. Set AC voltage decade selectors to desired range.

5. Adjust the DC substitution controls until the indicator shows zero percent error.

6. Using first the coarse and then the fine galvanometer keys, adjust the AC input balance controls until the galvanometer indicates a "null".

7. Turn transfer switch to AC input position.

8. Adjust the AC supply until the console galvanometer indicates a "null".

9. Read instrument under test.

f. AC VOLTS. -- (to read error)

1. Connect instrument and appropriate supply to the console as shown in Fig. 4A.

2. Set transfer switch to AC input position.

3. Set measurement selector to AC volts position.

4. Set AC voltage decade selectors to desired range.

5. Adjust supply until instrument indicates "on". (the desired point on its scale.)

6. Using first the coarse and then the fine galvanometer keys, adjust the AC input balance controls until the galvanometer indicates a "null".

7. Turn transfer switch to DC substitution position.

8. Adjust the DC substitution controls until the galvanometer indicates a "null".

9. Read percent error on error indicator.

g. AC CURRENT. -- (to calibrate)

1. Connect instrument and appropriate supply to the console as shown in Figure 4B.

2. Set transfer switch to DC substitution position.

3. Set measurement selector to AC current.

4. Set AC current decade selectors to the desired range.

5. Adjust the DC substitution controls until the indicator shows zero percent error.

6. Using first the coarse and then the fine galvanometer keys, adjust the AC input balance controls until the galvanometer indicates a "null".

7. Turn transfer switch to AC input position.

8. Adjust the AC supply until the galvanometer indicates a "null".

9. Read instrument under test.

h. AC CURRENT. -- (to read error)

1. Connect instrument and appropriate supply to the console as shown in Figure 4B.

2. Set transfer switch to AC input position.

3. Set measurement selector to AC current.

4. Set AC current decade selectors to the desired range.

5. Adjust power supply until meter indicates "on". (the desired point on its scale.) The being Calibrated.)

6. Using first the coarse and then the fine galvanometer keys, adjust the AC input balance ontrols until the galvanometer indicates a "null".

7. Turn transfer switch to DC substitution position.

8. Adjust the DC substitution controls until the galvanometer indicates a "null".

9. Read percent error on error indicator.

INSTRUCTIONS FOR INSTALLING GALVANOMETER

Model LTC or LTCA

Due to possibilities of damage in transit, the galvanometer for this instrument is shipped in a separate container. It must be installed in the test console in the following manner:

(1) Remove back panel from test set. This panel is held by screws around the edge which must be removed.

(2) Remove galvanometer from packing case, leave movement shorting wire connected to binding posts.

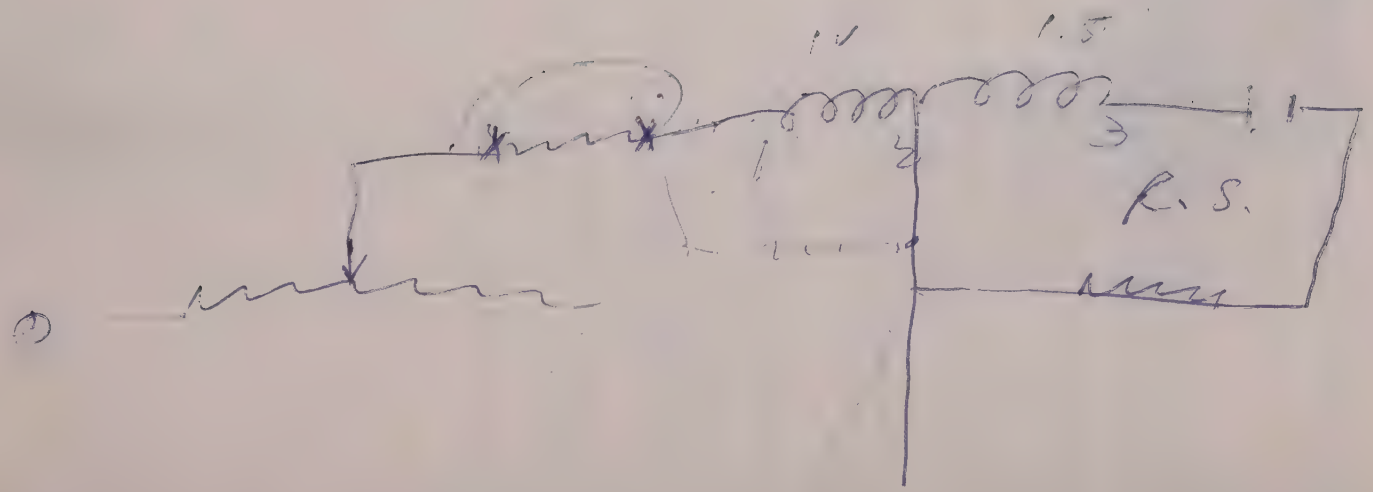
(3) Slide galvanometer into the shelf provided. (First remove galvanometer retaining strip connected to top of shelf side-plates.)

(4) Replace galvanometer retaining strip.

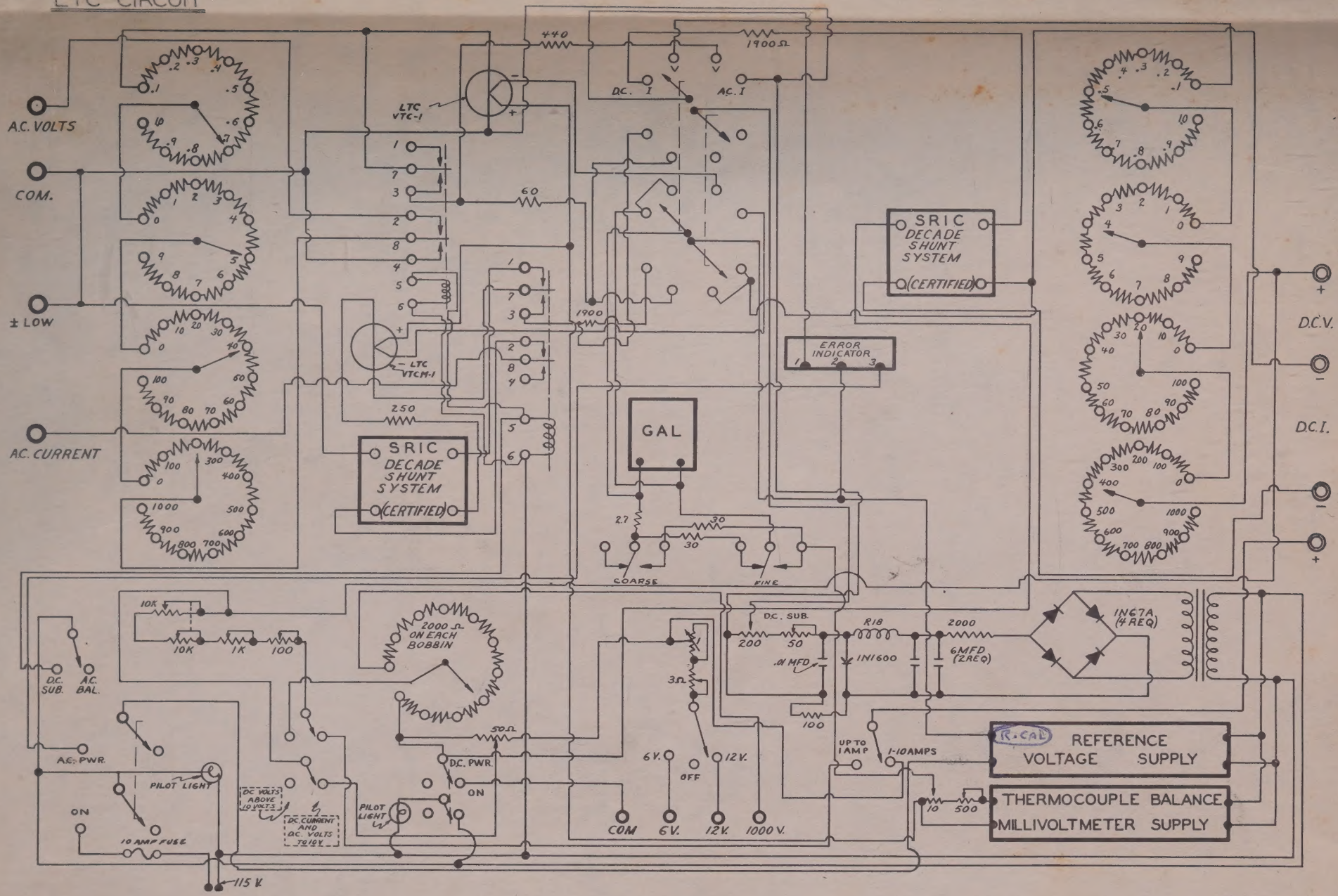
(5) Remove shorting wire from galvanometer binding posts and connect galvanometer leads. Tagged lead is connected to the binding post nearest the front panel.

(6) Plug galvanometer transformer cord into 6 volt socket on side of galvanometer.

(7) Replace back panel on console.


1.5
3
R. S.

LTC CIRCUIT


A.C. VOLTS
COM.
± LOW
A.C. CURRENT
LTC VTC-1
LTC VTCM-1
440
1900Ω
60
250
1900
DC. I
AC. I
SRIC DECADE SHUNT SYSTEM (CERTIFIED)
SRIC DECADE SHUNT SYSTEM (CERTIFIED)
ERROR INDICATOR
GAL
27
30
30
COARSE
FINE
D.C.V.
D.C.I.
10K
10K
1K
100
D.C. SUB.
A.C. BAL.
2000Ω ON EACH BOBBIN
50Ω
D.C. PWR.
ON
A.C. PWR.
PILOT LIGHT
ON
10 AMP FUSE
115 V.
DC VOLTS ABOVE 10 VOLTS
DC CURRENT AND AC VOLTS TO 10 V
PILOT LIGHT
3Ω
6 V.
OFF
12 V.
COM
6 V.
12 V.
1000 V.
D.C. SUB.
200
50
R18
2000
.01 MFD
IN1600
6MFD (ZREQ)
100
IN67A (4 REQ)
UP TO 1 AMP
1-10 AMPS
R.CAL
REFERENCE VOLTAGE SUPPLY
THERMOCOUPLE BALANCE MILLIVOLTMETER SUPPLY
10
500

545
Amitié
IVORY

92763

PGK 77 3514 12L

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